PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

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NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Assistant Commissioner for Patents
United States Patent and Trademark Office
Box PCT
Washington, D.C.20231
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing: 08 September 2000 (08.09.00)	
International application No.: PCT/GB00/00714	Applicant's or agent's file reference: 15386 LgCm
International filing date: 28 February 2000 (28.02.00)	Priority date: 02 March 1999 (02.03.99)
Applicant: INMAN, Michael	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International preliminary Examining Authority on:

20 July 2000 (20.07.00)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was
[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No.: (41-22) 740.14.35	Authorized officer: J. Zahra Telephone No.: (41-22) 338.83.38

Copy for the Elected Office (EO/US) PCT/GB00/00714

PATENT COOPERATION TREATY

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NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

From the INTERNATIONAL BUREAU

To:

LOFTING, Marcus, John
Accentus PLC
Patents Dept.
329 Harwell
Didcot
Oxfordshire OX11 0QJ
ROYAUME-UNI

Date of mailing (day/month/year) 25 July 2001 (25.07.01)	
Applicant's or agent's file reference 15386 LgCm	**IMPORTANT NOTIFICATION**
International application No. PCT/GB00/00714	**International filing date** (day/month/year) 28 February 2000 (28.02.00)

1. The following indications appeared on record concerning:

[ ] the applicant [ ] the inventor [X] the agent [ ] the common representative

Name and Address	State of Nationality	State of Residence
LOFTING, Marcus, John AEA Technology plc Patents Dept. 329 Harwell Didcot Oxfordshire OX11 0RA United Kingdom		
	Telephone No. 01235 43 2037	
	Facsimile No. 01237 43 6658	
	Teleprinter No.	

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

[ ] the person [ ] the name [X] the address [ ] the nationality [ ] the residence

Name and Address	State of Nationality	State of Residence
LOFTING, Marcus, John Accentus PLC Patents Dept. 329 Harwell Didcot Oxfordshire OX11 0QJ United Kingdom		
	Telephone No. 01235 43 2037	
	Facsimile No. 01237 43 6658	
	Teleprinter No.	

3. Further observations, if necessary:

4. A copy of this notification has been sent to:

[X] the receiving Office
[ ] the International Searching Authority
[ ] the International Preliminary Examining Authority
[ ] the designated Offices concerned
[X] the elected Offices concerned
[ ] other:

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland** Facsimile No.: (41-22) 740.14.35	Authorized officer HA Ki-Nam Telephone No.: (41-22) 338.83.38

Form PCT/IB/306 (March 1994) 004172723

PATENT COOPERATION TREATY

09/890157

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INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 15386 LgCm	**FOR FURTHER ACTION** see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. PCT/GB 00/ 00714	International filing date *(day/month/year)* 28/02/2000	(Earliest) Priority Date *(day/month/year)* 02/03/1999
Applicant AEA TECHNOLOGY PLC et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

[ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

[ ] contained in the international application in written form.

[ ] filed together with the international application in computer readable form.

[ ] furnished subsequently to this Authority in written form.

[ ] furnished subsequently to this Authority in computer readble form.

[ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

[ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of invention is lacking** (see Box II).

4. With regard to the **title,**

[X] the text is approved as submitted by the applicant.

[ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**

[X] the text is approved as submitted by the applicant.

[ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. ______

[ ] as suggested by the applicant.

[ ] because the applicant failed to suggest a figure.

[ ] because this figure better characterizes the invention.

[X] None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 00/00714

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B01D53/32 F01N3/08 B01J19/08 H05H1/24

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B01D F01N B01J H05H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	WO 99 43419 A (ANDREWS PETER JAMES ;HALL STEPHEN IVOR (GB); SHAWCROSS JAMES TIMOT) 2 September 1999 (1999-09-02) the whole document ---	1-27
X	EP 0 366 876 A (MITSUBISHI HEAVY IND LTD) 9 May 1990 (1990-05-09) column 9, line 9 -column 10, line 21; figures 2,3 ---	1-27
X	PATENT ABSTRACTS OF JAPAN vol. 016, no. 190 (C-0937), 8 May 1992 (1992-05-08) & JP 04 027414 A (MITSUBISHI HEAVY IND LTD;OTHERS: 01), 30 January 1992 (1992-01-30) abstract ---	1,24

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 May 2000	02/06/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Eijkenboom, A

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International Application No
PCT/GB 00/00714

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 954 320 A (BIRMINGHAM JOSEPH G ET AL) 4 September 1990 (1990-09-04) column 5, line 6 - line 20; figures 1-6	1-27

1

International Application No
PCT/GB 00/00714

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9943419 A	02-09-1999	AU 2535999 A	15-09-1999
EP 0366876 A	09-05-1990	JP 2115024 A	27-04-1990
		JP 2131123 A	18-05-1990
		AT 89187 T	15-05-1993
		DE 68906508 D	17-06-1993
		DE 68906508 T	09-09-1993
JP 04027414 A	30-01-1992	NONE	
US 4954320 A	04-09-1990	AU 4847690 A	08-04-1991
		CA 2021692 A	01-03-1991
		DK 78191 A	27-06-1991
		KR 9308083 B	25-08-1993
		NO 911683 A	26-06-1991
		WO 9103315 A	21-03-1991
		CA 1335806 A	06-06-1995

PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : B01D 53/32, F01N 3/08, B01J 19/08, H05H 1/24

A1

(11) International Publication Number: WO 00/51714

(43) International Publication Date: 8 September 2000 (08.09.00)

(21) International Application Number: PCT/GB00/00714

(22) International Filing Date: 28 February 2000 (28.02.00)

(30) Priority Data:
9904640.1 2 March 1999 (02.03.99) GB

(71) Applicant *(for all designated States except US)*: AEA TECHNOLOGY PLC [GB/GB]; 329 Harwell, Didcot, Oxfordshire OX11 0RA (GB).

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(75) Inventor/Applicant *(for US only)*: INMAN, Michael [GB/GB]; 2 Longfellow Drive, Abingdon, Oxfordshire OX14 5NU (GB).

(74) Agents: LOFTING, Marcus, John et al.; AEA Technology plc, Patents Dept., 329 Harwell, Didcot, Oxfordshire OX11 0RA (GB).

(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: PLASMA–ASSISTED PROCESSING OF GASEOUS MEDIA

(57) Abstract

A reactor for the plasma–assisted processing of a gaseous medium, including a pair of electrodes (1, 2) having facing surfaces the separation of which is substantially uniform, with a body (5) of dielectric material positioned between them and defining a plurality of gas passages (6) extending through the space between the electrodes.

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temperature of which is kept below a value at which the oxidation of N or NO to higher oxides of nitrogen does not occur. There is no mention of any simultaneous removal of hydrocarbons.

US patent 5 284 556 discloses the removal of hydrocarbons from internal combustion engine exhaust emissions. The process involved is one of dissociation in an electrical discharge of the so-called 'silent' type, that is to say, a discharge which occurs between two electrodes at least one of which is insulated. The device described is an open discharge chamber. Mention is made of the possible deposition of a NO_x-reducing catalyst on one of the electrodes.

A conventional dielectric barrier plasma assisted gas reactor such as that disclosed in specification US 5,284,556, consists of a plasma volume situated between two electrodes at least one of which has a dielectric barrier in the form of a thick layer of an insulating medium on its inner surface.

In order to generate a plasma in such a device, the potential within the space between the electrodes must reach a critical value before the plasma will ignite. The potential which appears across the main plasma volume is dependent upon the ratio of the capacitance of the dielectric layer and that of the plasma volume because these two entities create a capacitive potential divider. The potential across the plasma volume is inversely proportioned to its capacitance, that is to say, the higher the capacitance of the plasma volume, the lower is the potential difference across it. This effect can cause a serious problem if the plasma volume is filled with a gas permeable material which has a high dielectric

constant, such as pellets of barium titanate, because the potential difference across such a reactor bed may never reach the critical value for the plasma to ignite unless the supply voltage is very high, of the order of tens of kilovolts which may exceed the safe working voltage of the dielectric barrier, or other high voltage components of the power supply.

It is an object of the present invention to provide an improved reactor for the plasma-assisted processing of a gaseous medium.

According to the invention in one aspect there is provided a reactor for the plasma assisted processing of a gaseous medium including a pair of electrodes having facing surfaces, the separation of the facing surfaces being substantially uniform and defining a space therebetween, and a body of dielectric material positioned between the electrodes so as to divide the said space therebetween into a plurality of gas passages the lengths of which extend between the facing surfaces of the electrodes and which gas passages are spaced apart from one another in a direction transverse to the said facing surfaces so that a substantially uniform distribution of electric field occurs across the space between the electrodes.

According to the present invention in a second aspect there is provided a reactor wherein the electrodes are embedded in a body of dielectric material which extends across the space between the electrodes and includes a plurality of gas passages extending longitudinally of the body of dielectric material to provide a plurality of electrically equivalent plasma volumes extending in series across the space between the electrodes.

Preferably the matrix of gas passages in the dielectric medium between the electrodes is adapted to provide a potential difference across the space between the electrodes equal to half the supply voltage. The potential difference across the space will vary according to gas flow, temperature and gas composition and therefore the overall size and shape and position of location of the reactor within the exhaust system is selected so as to ensure that variances from this optimum condition are minimized.

The surfaces of the gas passages can be coated, impregnated or generally treated by for example ion exchange or doping with a material which is catalytically active in relation to the gas and or particulate processing reactions to be carried out in the reactor, or the gas passages can be filled with a gas permeable form of such a material. The geometry of the gas passages or the gas permeable filling material, which may be dielectric, can then be adapted to negate the capacitive effects of the catalytic material. Alternatively, the dielectric material of the reactor can itself be chosen to be catalytic in relation to the gas and or particulate processing reactions to be carried out in the reactor. The gas permeable material filling the passages can be catalytically-active or non-catalytically thermally-active with respect to processing of the gaseous medium although a catalytically-active material may be present on the surface of non-catalytic dielectric material contained in the reactor as a coating or it may be present on or in the gas permeable filling material by generally treating the material by for example ion exchange or doping.

Gas permeable dielectric filling material for the reactor can be in the form of spheres, pellets, extrudates, fibres, sheets, wafers, frits, meshes, coils, foams, membrane, ceramic honeycomb monolith or granules or as a coating on any of the above shapes or on a ceramic foam or ceramic honeycomb monolith. In addition to optimising the plasma discharge and gas processing characteristics, combinations of one or more of the above can be used to create a filter structure with a non-uniform surface area and porosity, for example a graded porosity when presented to the exhaust gas particularly when containing particulates as described in patent specification PCT/GB00/00079. Gas permeable dielectric filling material that can be placed inside the reactor can also be housed outside of the plasma region of the reactor so that the gaseous media can either pass through this material before entering the plasma region or pass through this material after passing through the plasma region. When placed outside the reactor, dielectric filling material can be replaced by ceramic, polymeric or metallic material in the same form described above for the dielectric filling material. Dielectric filling material can act as a selective filter as described in the specification of our applications GB 99 24999.7 and GB 99 29771.5. respectively. Dielectric material or trapped species on it in the plasma can be made to appear to act as a catalytic surface to the gas processing reactions even though neither the plasma nor the dielectric material nor trapped species alone need have catalytic properties as described in the specification of our application GB 99 29771.5.

When the gaseous medium comprises the exhaust gases containing nitrogenous oxides and particulate material such as carbonaceous particulate that are derived from an internal combustion engine supplied with combustion fuel,

the exhaust gases can contain hydrocarbon either added separately or residually derived from the fuel combustion. The exhaust can contain a chemical additive acting as a carbon combustion catalyst that is either present initially in the fuel or added separately to the exhaust and whose function is to lower the combustion temperature and/or increase the rate of removal of carbonaceous material. Carbon combustion catalyst can be encapsulated within or bound to a fugitive additive that chemically decomposes during or shortly after fuel combustion thus releasing the additive into the fuel or exhaust. Examples of carbon combustion catalysts are alkali-metal salts such as lithium nitrate described in GB 2 232 613 B, cerium oxide, alkali-metal doped lanthanum oxide-vanadium oxide, perovskites such as $La_{0.9}K_{0.1}CoO_3$ and also layered perovskites or vanadate or combinations of such materials although such carbon combustion catalysts can also constitute all or part of the dielectric filling material described above. The mode of operation of such catalysts is described in our specification PCT/GB00/00079. The use of a carbon combustion catalyst can reduce the power requirements to the plasma reactor for treating carbonaceous particulate material and reduce the volume of active material.

For the reduction of nitrogenous material for which zeolites are particularly useful materials, the plasma can produce activated hydrocarbon from hydrocarbon reductant in the exhaust as described in our publication WO99/12638 and/or convert nitrogenous oxides to nitrogen dioxide as described in WO99/12638 and PCT/GB00/00079. It should be appreciated that material that is not catalytic for the reduction of nitrogenous material when not exposed to a plasma may develop catalytic properties for this reduction when exposed to a plasma due for

example to activation by O atoms or other plasma-generated free radicals or activation by plasma generated species such as activated hydrocarbons and or nitrogen dioxide. It should be appreciated that the dielectric filling material can also be placed outside the plasma zone and outside the reactor with a multiplicity of additive injection ports as described in WO99/12638. Catalytic properties can be further augmented by the electric field and or other charged species present in or adjacent to the plasma region. A reductant other than hydrocarbon may be used, in particular nitrogen containing species such as ammonia, urea or cyanuric acid. When a nitrogen containing species is used as a reductant for nitrogeneous oxide reduction a particularly useful catalyst is vanadium pentoxide-titanium dioxide. When using a nitrogen containing reductant species, mixing with effluent can also be made after the effluent has passed through the plasma zone of the reactor before contact with the catalyst.

The invention will now be described, by way of example, with reference to the accompanying drawings, in which

Figure 1 is a perspective view of the operative part of a reactor embodying the invention for the plasma assisted processing of a gaseous medium, and

Figure 2 is a transverse section of a second embodiment of the invention.

Referring to Figure 1 of the drawings, the operative part of a reactor for the plasma assisted processing of a gaseous medium includes two planar electrodes 1 and 2 to one of which is connected a high voltage supply cable 3. The other electrode has a cable 4 connected to it by

WO99/05400 and the specification of our application PCT/GB00/00108.

If desired, the gas channels 6 can be filled with a gas permeable body made of an insulating material which is catalytic or non-catalytic towards the gas and or particulate processing reactions to be carried out in the reactor. Alternatively, the surfaces of the gas passages 6 or gas permeable filling material can be coated with such a catalytic material, or the entire body of dielectric can be made of such a material. The choice of material, which can by itself be catalytic or non-catalytic in the presence or absence of the plasma, depends on the requirements to process nitrogeneous oxides or particulate material and other emissions described previously. Dielectric material or trapped species on it in the plasma can be made to appear to act as a catalytic surface to the gas processing reactions even though neither the plasma nor the dielectric material nor trapped species alone need have catalytic properties. Gas permeable dielectric filling material that can be placed inside the reactor can also be housed outside of the plasma region of the reactor so that the gaseous media can either pass through this material before entering the plasma region or passes through this material after passing through the plasma region. It will be appreciated that the same material can be used in the plasma zone as outside the plasma zone or combinations of different materials can be used in the plasma zone and outside the plasma zone and that exhaust gas and or particulate processing reactions can be carried out by combinations of identical or different materials in or out of the plasma zone.

In practice, of course, the operative part of the reactor is contained in an envelope which includes inlet

and outlet stubs by means of which it can be incorporated in pipework through which the gaseous medium to be processed is caused to flow and means for ensuring that all the said gaseous medium passes through the gas passages 6.

Although the invention has been described in terms of a planar geometry as shown in figure 1, it is equally applicable to a cylindrical geometry as shown in Figure 2, although in this case, the radial thicknesses of the gas passages will have to vary in order that a uniform radial potential drop be achieved. The embodiments of reactor described in these examples may include catalytic components or be installed as part of an emissions control system employing catalysts or other emission control devices for the plasma assisted treatment of the exhaust gases from internal combustion engines. Such other emission control devices may comprise exhaust gas recirculation (EGR), variations in ignition timing, fuel injection timing and fuel injection pulse rate shaping. The reactor of these examples can be used in conjunction with a power supply and engine management system as described in the specification of our application PCT/GB00/(Filing data awaited Ref:15367 LgCm priority from GB99 04069.3). An article 'Stop go systems get the green light' in European Automotive Design, April 1998, pages 24-26 describes an example of an integrated starter alternator damper system (ISAD). Such an ISAD can be used as part of a power supply system to power a plasma assisted emissions control system of which a reactor as described herein is part. In addition, other power sources such as but not limited to fuel cells, gas turbines, solar cells and heat exchangers can be the primary or part-provider of the electrical-generating power source that can also be used to power the power supply system for the reactor.

the body 5, are alpha and gamma aluminas, cordierite, mullite, alumino silicate ceramics, silicon carbide, micaceous moldable ceramics such as MICATHERM or mixtures of these. Suitable catalytic material that can be used for coating the surfaces of the gas channels 6, or for use as the dielectric filling material or for depositing onto the dielectric filling material, for example as a coating, are aluminas known as LD 350, CT 530, Condea hollow extrudates, DYPAC, T-60 Alumina, T-162 alumina cordierite, α, χ and γ aluminas, and aluminas containing mixtures of these phases, ferroelectric materials such as titanates particularly barium titanate; titania, particularly in the anatase phase; zirconia, vanadia, silver aluminate, perovskites, spinels, metal-doped and metal oxide-doped or exchanged inorganic oxides such as cobalt oxide-doped alumina, vanadates and pyrovanadates and metal-doped zeolites. Examples of zeolites are those known as ZSM-5, Y, beta, mordenite all of which may contain iron, cobalt or copper with or without additional catalyst promoting cations such as cerium and lanthanum. Other examples of zeolites are alkali metal containing zeolites in particular sodium-Y zeolites that are particularly useful for treatment of nitrogeneous oxides. Examples of perovskites are La_2CuO_4, $La_{1.9}K_{0.1}Cu_{0.95}V_{0.05}O_4$ and $La_{0.9}K_{0.1}CoO_3$. Examples of vanadates are potassium metavanadate, caesium metavanadate, potassium pyrovanadate and caesium pyrovanadate. Mixtures of these compounds can also be used.

Gas permeable dielectric filling material for the reactor can be in the form of spheres, pellets, extrudates, fibres, sheets, wafers, frits, meshes, coils, foams, membrane, ceramic honeycomb monolith or granules or as a coating on a ceramic foam or ceramic honeycomb monolith. Combinations of one or more of the above can be

Claims

1. A reactor for the plasma assisted processing of a gaseous medium including a pair of electrodes (1,2;21,22) having facing surfaces, the separation of the facing surfaces being substantially uniform and defining a space therebetween, characterised by a body (5;23) of dielectric material positioned between the electrodes (1,2;21,22) so as to divide the said space therebetween into a plurality of gas passages (6;24) the lengths of which extend between the facing surfaces of the electrodes (1,2;21,22) and which gas passages are spaced apart from one another in a direction transverse to the said facing surfaces so that a substantially uniform distribution of electric field occurs across the space between the electrodes (1,2;21,22).

2. A reactor according to claim 1, further characterised in that the electrodes (1,2;21,22) are embedded in a body (5;23) of dielectric material which extends across the space between the electrodes (1,2;21,22) and includes a plurality of gas passages (6;24) extending longitudinally of the body (5;23) of dielectric material to provide a plurality of electrically equivalent plasma volumes extending in series across the space between the electrodes (1,2;21,22).

3. A reactor according to claim 1 or claim 2, further characterised in that the dielectric material is selected from the group consisting of alpha or gamma aluminas, cordierite, mullite, alumino silicate ceramics, silicon carbide, micaceous glass or mixtures of these.

4. A reactor according to claim 1 or claim 2 or claim 3, further characterised in that the gas passages (6;24)

in the form of two concentric cylinders and the gas passages(24) comprise a plurality of regularly spaced slots of cylindrical form.

15. A reactor according to any of the preceding claims, further characterised in that the arrangement of gas passages(6,24) is such that the potential drop across the space between the electrodes is equal to approximately half the voltage applied to the reactor.

16. A reactor according to any of the preceding claims, further characterised in that power supply for the reactor is provided by an integrated starter alternator damper system.

17. A reactor according to any of claims 1 to 15, further characterised in that fuel cells, gas turbines, solar cells or heat exchangers are used as primary or part-provider of an electrical-generating power supply for the reactor.

18. A reactor according to any of the preceding claims incorporated as part of an emissions control system.

19. A reactor according to claim 18, further characterised in that the emissions control system is used in conjunction with an engine management system.

20. A reactor according to claim 18 or claim 19, further characterised in that the emissions control system includes an additional gas passage outside of the plasma region of the reactor in series with the aforesaid gas passages(6,24), said additional gas passage containing gas permeable catalytically active material.

09/890157

PATENT COOPERATION TREATY

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REC'D 31 MAY 2001
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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 15386 LgCm	**FOR FURTHER ACTION**	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/GB00/00714	International filing date *(day/month/year)* 28/02/2000	Priority date *(day/month/year)* 02/03/1999
International Patent Classification (IPC) or national classification and IPC B01D53/32		
Applicant AEA TECHNOLOGY PLC et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 5 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 14 sheets.

3. This report contains indications relating to the following items:

   I ☒ Basis of the report
   II ☐ Priority
   III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   IV ☐ Lack of unity of invention
   V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   VI ☐ Certain documents cited
   VII ☒ Certain defects in the international application
   VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
20/07/2000	29.05.2001
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Eijkenboom, A Telephone No. +49 89 2399 8616

Form PCT/IPEA/409 (cover sheet) (January 1994)

I. Basis of the r port

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:

Description, pages:

1,2,9,12,14,15	as originally filed			
3-8,8a,10,11,13, 13a	as received on	24/02/2001	with letter of	20/02/2001

Claims, No.:

5-13,14 (part), 21-27	as originally filed			
1-4,14 (part), 15-20	as received on	24/02/2001	with letter of	20/02/2001

Drawings, sheets:

1/1	as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

☐ the description, pages:

☐ the claims, Nos.:

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-27
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-27
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-27
	No:	Claims	

2. Citations and explanations
see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

Ad Section V:

1. JP-A-4.027.414 (D2) constitutes the closest prior art and refers to a plasma reactor comprising a pair of electrodes (1), parallel to the direction of gas flow, provided on both sides of a dielectric material (2) provided with a plurality of tubular holes (4). The tubular holes (4) provide gas passages which are aligned in a direction parallel with the facing surfaces of the electrodes (1).

   The plasma reactor of current claim 1 differs from the one in D2 in that the gas passages are shaped so as to have a pair of opposite sides the contour of which matches the contour of the facing surfaces of the electrodes. This shape effects a substantially uniform distribution of electric field across the plasma volume space between the electrodes.

   Since none of the cited prior art hints to shaping gas passages in such a way for that purpose, the subject-matter of claim 1 is considered novel and inventive (Art.33(2) & (3) PCT).

   EP-A-0.366.876 (D1) discloses a plasma reaction vessel (5) having a pair of plate-shaped electrodes (10,11). A porous dielectric member (9) is installed in the space between the electrodes (10,11). The planes of the electrodes (10,11), however, extend substantially perpendicular to the direction of gas flow, although figure 3 shows that the dielectric member (9) is provided with a plurality of gas passages extending between the facing surfaces of the electrodes (10,11). The reactor of D1 is used for the treatment of nitrogenous oxides in the presence of a reductant.

   US-A-49.54.320 (D3) discloses a plasma reactor with electrodes arranged in parallel to the gas flow and a gas permeable dielectric filling material in the space between the electrodes. D3 lacks an indication to gas passages extending in parallel to the facing surfaces of the electrodes.

2. Claims 2-23 are dependent on claim 1 and as such also meet the requirements of the PCT with respect to novelty and inventive step.

   Independent claim 24 and its dependent claims 25-26 are based on a method for using a reactor according to any of the claims 1-23 and, hence, also fulfill the requirements of the PCT with respect to novelty and inventive step.

Ad Section VII:

1. In the description, page 7, reference is made to patent application PCT/GB00/3943 without proper indication of its publication number (WO-A-00/130485).